The Utility of Administrative Data for Surveillance of Comorbidity in Multiple Sclerosis: A Validation Study

Ruth Ann Marrie\textsuperscript{a, b} Bo Nancy Yu\textsuperscript{b} Stella Leung\textsuperscript{b} Lawrence Elliott\textsuperscript{b} Patricia Caetano\textsuperscript{b} Sharon Warren\textsuperscript{c} Christina Wolfson\textsuperscript{f, g} Scott B. Patten\textsuperscript{h} Lawrence W. Svenson\textsuperscript{d, e, h} Helen Tremlett\textsuperscript{i} John Fisk\textsuperscript{j} James F. Blanchard\textsuperscript{b}

for the CIHR Team in the Epidemiology and Impact of Comorbidity on Multiple Sclerosis

Departments of \textsuperscript{a}Internal Medicine and \textsuperscript{b}Community Health Sciences, University of Manitoba, Winnipeg, Man., \textsuperscript{c}Faculty of Rehabilitation Medicine and \textsuperscript{d}School of Public Health, University of Alberta, and \textsuperscript{e}Surveillance and Assessment, Alberta Health and Wellness, Edmonton, Alta., \textsuperscript{f}Department of Epidemiology and Biostatistics, McGill University, and \textsuperscript{g}Research Institute of the McGill University Health Centre, Montreal, Que., \textsuperscript{h}Department of Community Health Sciences, University of Calgary, Calgary, Alta., \textsuperscript{i}Department of Medicine (Neurology), University of British Columbia, Vancouver, B.C., and \textsuperscript{j}Departments of Psychiatry and Medicine, Dalhousie University, Halifax, N.S., Canada

Key Words
Multiple sclerosis · Administrative data · Validation · Prevalence · Comorbidity inflammatory bowel disease · Irritable bowel syndrome · Migraine · Epilepsy · Lung disease

Abstract

Background: Although comorbidity is important in multiple sclerosis (MS), few validated methods for its assessment exist. We validated and applied administrative case definitions for several comorbidities in MS. Methods: Using provincial administrative data we identified persons with MS and a matched general population cohort. Case definitions for chronic lung disease (CLD), epilepsy, inflammatory bowel disease (IBD), irritable bowel syndrome (IBS) and migraine were developed using administrative data, and validated against medical records. We applied these definitions to estimate the age-standardized prevalence of these comorbidities in the MS and matched cohorts. Results: Versus medical records, administrative case definitions showed moderate agreement for CLD ($\kappa = 0.41$), migraine ($\kappa = 0.51$), and epilepsy ($\kappa = 0.44$), fair agreement for IBS ($\kappa = 0.36$) and could not be calculated for IBD (small sample size). The 2005 prevalence of CLD was similar in the MS (15.6%) and general populations (14.4%). The prevalence of the remaining comorbidities was higher in the MS than the general populations: epilepsy (4.12 vs. 1.12%), IBD (0.78 vs. 0.65%), IBS (12.2 vs. 6.80%) and migraine (23.0 vs. 16.5%). Conclusions: Administrative data are valid for tracking CLD, epilepsy, and migraine in MS. The prevalence of epilepsy, IBD, IBS and migraine is increased in MS versus the general population.

Copyright © 2012 S. Karger AG, Basel
Introduction

Increasing evidence suggests that comorbidities commonly affect individuals living with multiple sclerosis (MS) and adversely affect clinical outcomes [1]. A better understanding of comorbidities may highlight common etiologic factors or provide opportunities to individualize treatment, as in the management of hypertension [2]. However, the prevalence, impact, and methods for identifying some comorbidities in MS remain poorly characterized [1].

Potential comorbidity data sources include self-report, medical records, and administrative databases. The validity of self-reported comorbidity data in persons with MS varies by condition [3]. Medical records reviews are costly and labor-intensive, often prohibiting their use in large studies. Administrative data are accessible, cost-effective and cover large populations, potentially supporting research questions which cannot be addressed using interviews or records review. Moreover, in publicly funded health systems they are population-based. Administrative data, however, are collected for health system management and payment. Since the validity of administrative definitions for chronic disease is variable [4, 5] and may be affected by the presence of other chronic conditions such as MS, the use of administrative data for studying chronic disease must be assessed.

We aimed to validate administrative definitions for several comorbidities of potential importance in MS, and to describe their prevalence among persons with MS versus a matched cohort from the general population (GPOP). Herein we focused on chronic lung disease (CLD), epilepsy, inflammatory bowel disease (IBD), irritable bowel syndrome (IBS), and migraine because they have been reported to adversely affect quality of life in MS or to be more common in persons with MS than in the GPOP [6–8], and generally lack population-based prevalence estimates. We hypothesized that administrative data are a valid data source for studying some comorbidities in MS.

Methods

This study was conducted in Manitoba, a Canadian province with a population of 1.2 million, using anonymized administrative data obtained from Manitoba Health.

Administrative Data

Manitoba Health oversees health care services for >98% Manitoba residents [9]. Since 1984, Manitoba Health has maintained computerized records of health services claims which are linkable by a unique personal health identification number (PHIN) for the person to whom service was provided. A population registry is updated when an individual moves into or out of Manitoba, or dies. Each physician claim includes the PHIN, service date, and three-digit International Classification of Disease (ICD)-9-CM code for one physician-assigned diagnosis. Since 2004 each hospitalization record includes the PHIN, admission and discharge dates, and up to 16 discharge diagnoses listed using ICD-10-CA codes. Before 2004, these diagnoses used five-digit ICD-9-CM codes. Since 1996, the Drug Programs Information Network captures outpatient prescription drug dispensations including the date, drug name, and drug identification number for Manitoba residents, regardless of insurance coverage or payer.

Validation Cohort

As described previously, 430 persons with MS self-reported comorbidities [3, 10], and their medical records were reviewed by a trained abstractor using a standardized data collection form. These clinical data were linked via each participant’s PHIN with the administrative databases to create a validation cohort.

Administrative Case Definitions

Previously we developed case definitions for vascular comorbidities and autoimmune thyroid disease [5, 11]. We identified ICD-9/10 codes for these conditions, and listed prescription medications using the Anatomic Therapeutic Chemical system (online suppl. table 1; for all online suppl. material, see www.karger.com/doi/10.1159/000343188). By varying the number of physician, hospital and prescription claims required and the years of data required to classify a person as being affected we developed several case definitions for each condition (labeled alphabetically). Because few members of our validation cohort had IBD, we used a previously validated Canadian definition [12], requiring ≥5 hospital or physician claims with ICD-9/10 codes of (555, 556, K50, K51), or ≥3 hospital or physician claims if they were resident in Manitoba for <2 years.

Using the validation cohort, we compared the classification of comorbidity according to the administrative case definitions versus diagnoses based on medical records review for the 1- to 5-year periods ending in fiscal year 2005/06. We report a kappa (κ) statistic for agreement between administrative and medical records data [13], aiming to identify the case definition which maximized κ. We interpreted κ as follows: slight (0–0.20), fair (0.21–0.40), moderate (0.41–0.60), substantial (0.61–0.80), and almost perfect agreement (0.81–1.0) [13]. We computed sensitivity, specificity, positive predictive value and negative predictive value for admin-
istrative definitions versus the 'gold standard' of medical records review to identify whether an algorithm would be vulnerable to over- or underestimation of the prevalence of a comorbidity.

**Prevalence**

For each condition, we report the prevalence in the MS and GPOP cohorts. Once a person met the case definition for a comorbidity, she was considered affected in all subsequent years while alive and resident in Manitoba. We estimated the point prevalence of the comorbidity on October 1, 2005 using the mid-year population figures for denominators and also calculated prevalence ratios. To enhance comparability with other study populations, we used the direct method to age-standardize findings to the 2001 Canadian population, and calculated 95% confidence intervals (CI) using the exact binomial distribution.

The University of Manitoba Health Research Ethics Board and the Manitoba Health Information Privacy Committee approved the study and data access. All participants in the validation cohort provided written informed consent. Statistical analyses used SAS 9.2 (SAS Institute Inc., Cary, N.C., USA).

**Results**

The MS population included 4,192 persons, while the matched GPOP cohort included 20,940 persons. Table 1 shows the characteristics of the cohorts at baseline and in 2005. In the validation cohort most participants were white (91.6%), women (77.0%), with a mean (standard deviation) age at symptom onset of 33.2 (11.1) years [5]. Based on records review 6.9% of participants in the validation cohort had CLD, while 9.6% had CLD based on self-report. For the other comorbidities we found (medical records/self-report): epilepsy (2.2/1.5%); IBS (6.3/11.1%); IBD (0.49/2.1%) and migraine (12.2/15.7%).

**Chronic Lung Disease**

The administrative case definitions for CLD are shown in online supplementary table 2, labeled as ‘A’ to ‘J’. The definitions using only 1 year of data were highly specific but insensitive, even those requiring only one hospital or physician claim (sensitivity 8.7%). Further, agreement between these case definitions and medical records was ‘slight’. The highest level of agreement achieved was ‘moderate’ (maximum \( \kappa = 0.41 \)) for definition ‘H’ (\( \geq 1 \) hospital or \( \geq 2 \) physicians or \( \geq 2 \) prescription claims in 5 years), and had a sensitivity of 69.6% and specificity of 91.9%. Removing prescription claims reduced the sensitivity by 30.5%, and increased specificity by only 3.4% (definition ‘J’).

Using definition ‘H’ the age-standardized prevalence (95% CI) of CLD in 2005 was 15.6% (14.3–17.0%) in the

| Characteristic | MS population | GPOP | | | |
|----------------|----------------|----------------|----------------|----------------|
| | at time of 1st claim | 2005 | at time of 1st claim | 2005 |
| | (n = 4,192) | (n = 3,111) | (n = 20,940) | (n = 16,395) |
| Female | 3,006 (71.7) | 2,306 (74.1) | 15,019 (71.7) | 12,011 (73.3) |
| ≤24 | 322 (7.7) | 48 (1.5) | 1,618 (7.7) | 250 (1.5) |
| 25–29 | 411 (9.8) | 120 (3.9) | 2,046 (9.8) | 623 (3.8) |
| 30–34 | 542 (12.9) | 183 (5.9) | 2,739 (13.1) | 928 (5.7) |
| 35–39 | 658 (15.7) | 264 (8.5) | 3,229 (15.4) | 1,379 (8.4) |
| 40–44 | 604 (14.4) | 411 (13.2) | 3,015 (14.4) | 2,025 (12.3) |
| 45–49 | 494 (11.8) | 465 (14.9) | 2,481 (11.8) | 2,316 (14.1) |
| 50–54 | 364 (8.7) | 487 (15.6) | 1,838 (8.8) | 2,476 (15.1) |
| 55–59 | 301 (7.2) | 413 (13.3) | 1,490 (7.1) | 2,173 (13.2) |
| 60–64 | 211 (5.0) | 265 (8.5) | 1,059 (5.1) | 1,426 (8.7) |
| ≥65 | 285 (6.8) | 455 (14.6) | 1,425 (6.8) | 2,799 (17.1) |
| Residence in Winnipegc | 2,076 (58.1) | 1,919 (62.0) | 10,197 (57.5) | 9,651 (59.5) |

a No difference in age, sex or geographic distribution between the MS population and GPOP at the time of the first demyelinating disease claim (all p > 0.05).

b In 2005, the proportion of persons aged 65 years and older was lower among the MS population (p = 0.0008) and the proportion of persons living in Winnipeg, the only urban center with a population >50,000, was higher among the MS population (p = 0.0033).

c Some participants lacked a regional code at one of the specified time points.
MS population. Although this exceeded the prevalence in the GPOP, the CIs overlapped (14.4%; 13.8–15.0%). The prevalence of CLD increased with age in both populations (fig. 1).

**Epilepsy**

The case definitions for epilepsy are labeled as ‘A’ to ‘L’ in online supplementary table 3. The most sensitive definition (66.7%) required \( \geq 2 \) hospital or physician or prescription claims over 2 years but was the least specific (74.9%). Several definitions had specificities of \( >90\% \). The highest levels of agreement achieved were ‘moderate’ (\( \kappa = 0.40 \)) for definition ‘H’ (\( \geq 1 \) hospital or physician claim and \( \geq 1 \) prescription claims over 3 years), and for definition ‘I’ (\( \geq 1 \) hospital or physician claim plus \( \geq 2 \) prescription claims over 3 years, \( \kappa = 0.44 \)). These definitions had sensitivities of 55.6% and specificities of 97.5 and 97.9%, respectively. Removing prescription claims resulted in only fair agreement being achieved (maximum \( \kappa = 0.29 \)), for definitions ‘G’ which required \( \geq 1 \) hospital or physician claims over 3 years (sensitivity 55.6% and specificity 95.5%) and ‘K’ which required \( \geq 1 \) hospital or \( \geq 2 \) physician claims over 5 years (sensitivity 44.4% and specificity 95.5%). Generally, adding prescription claims enhanced sensitivity and agreement with medical records without loss of specificity.

Applying definition ‘H’, the age-standardized prevalence of epilepsy in 2005 was 4.12% (3.42–4.82%) in the MS population, 3-fold higher than in the GPOP (1.12%; 0.96–1.29%). In the MS population the prevalence was similar in men (3.76%; 2.73–5.20%) and women (4.88%; 4.10–5.81%) and varied slightly across age groups (fig. 1).

**Inflammatory Bowel Disease**

In 2005, the age-standardized prevalence of IBD in the MS population was 0.78% (0.48–1.07%), higher than in the GPOP (0.65%; 0.53–0.77%). The prevalence of IBD was similar in men (0.98%; 0.35–1.61%) and women (0.72%; 0.38–1.05%) with MS, and in men (0.67%; 0.47–0.87%) and women (0.66%; 0.52–0.81%) from the GPOP. In the MS population, the peak prevalence of IBD occurred at age 45–59 years (fig. 1).

**Irritable Bowel Syndrome**

We tested several case definitions for IBS, all with specificities of \( \geq 94\% \) (data not shown). As compared to medical records, the most sensitive definition was \( \geq 1 \) hospital or \( \geq 2 \) physician claims in 2 years (39.1%; 19.7–61.4%). This definition had a specificity of 96.6% (94.2–98.2%), a positive predictive value of 40.9% (20.7–63.6%), and a negative predictive value of 96.3% (93.9–98.0%), and the highest level of agreement (\( \kappa = 0.36; 0.18–0.55 \)).

Using this definition the age-standardized prevalence of IBS in 2005 was 12.2% (11.0–13.5%) in the MS population, nearly 2-fold higher than in the GPOP (6.80%; 6.39–7.21%). In both populations the prevalence of IBS was higher in women than in men (prevalence ratio 1.76; 1.16–2.68), and the peak prevalence was seen in persons aged \( \geq 60 \) years.

**Migraine**

Agreement between the administrative definitions (labeled A–U) and medical records varied from slight to moderate (\( \kappa = 0.11–0.51 \), online supplementary table 4). The definition with the highest level of agreement required \( \geq 2 \) hospital or physician or prescription claims in 2 years (definition ‘F’, \( \kappa = 0.51 \)). Agreement was similar
for definitions which used ≥3 hospital or physician or prescription claims over 2, 3, 4 or 5 years. Definition ‘F’ had a modest sensitivity of 54% but a specificity of 94.9%. Prescription claims enhanced the sensitivity of the case definitions without adversely affecting specificity. The highest level of agreement for a definition which did not use prescription claims (definition ‘I’) was only fair (κ = 0.38).

Using definition ‘F’ age-standardized prevalence of migraine in 2005 was 23.0% (21.4–24.6%) in the MS population and 16.5% (15.9–17.1%) in the GPOP. The prevalence of migraine was more than 6-fold higher among women (29.4%; 27.3–31.5%) than men with MS (4.68%; 3.44–5.93%). Similarly, the prevalence of migraine was 8-fold higher in women (21.4%; 20.6–22.3%) from the GPOP than men (2.52%; 2.08–2.96%). The prevalence of migraine declined substantially among those aged ≥60 years (fig. 1).

**Discussion**

Previously we demonstrated substantial agreement between self-report and medical records (all κ ≥0.78) for comorbid hypertension, hyperlipidemia, diabetes, and thyroid disease among MS patients [3, 11], and substantial agreement of administrative data with medical records review (κ = 0.69–0.75) for these conditions [5]. The administrative definitions for three of the comorbidities evaluated in this study showed more modest agreement (κ) with medical records, being moderate for CLD (0.41), epilepsy (0.44), and migraine (0.51). Nonetheless, specificities were uniformly high, exceeding 90% (summarized in table 2). Thus, while these definitions may underestimate the burden of these comorbidities in the MS population due to modest sensitivity, they will be unlikely to overestimate disease burden and can be useful for disease surveillance. Collectively our work suggests that administrative data can provide a broad view of health status in MS.

Under-reporting of comorbidities in administrative data may occur due to coding biases in hospital claims [14]. Since physician claims in Manitoba only code one (most responsible) diagnosis, sensitivity of our case definitions might be higher in jurisdictions where physician claims allow coding of multiple diagnoses. Single-diagnosis coding also makes it important to re-validate case definitions when applying them to different populations. We showed that the Canadian case definition for diabetes surveillance is less sensitive in the MS population than in the GPOP [5]. This might be overcome by using prescription claims, although using such data is challenging when medications may be used for off-label indications in MS, such as migraine and epilepsy. Nonetheless, adding prescription claims enhanced sensitivity of our case definitions without a significant loss of specificity. Unfortunately, such data are not available in all jurisdictions and further evaluation of our case definitions across other jurisdictions is needed.

The worst-performing case definition was that for IBS where agreement was only fair (κ = 0.36) with a sensitivity of 39.1%, illustrating potential challenges in creating administrate case definitions. Administrative definitions for IBS relying on one encounter with a four-digit ICD-9 code of 564.1 have a reported sensitivity of 98.9% and positive predictive value of 91.3% [15], though other studies have reported specificities of 63–83% [16, 17]. However, using the broader three-digit ICD-9-CM code ‘564’,
functional disorders not classified elsewhere, as available for physician claims in Manitoba, resulted in only poor to fair agreement between self-report and one encounter ($\kappa = 0.11–0.22$) [4]. While our definition which required $\geq 2$ hospital or physician claims in 2 years resulted in some improvement, it still reached only ‘fair’ agreement ($\kappa = 0.36$), with high specificity, and likely underestimates the burden of IBS in both populations.

Chronic gastrointestinal diseases are common in the GPOP, and cause substantial morbidity [18]. We found the prevalence of IBS to be 2-fold higher in the MS population than in the GPOP. We are aware of two other studies that examined the prevalence of IBS in MS. Both used the same questionnaire and found similar prevalence, with 9.4–12.8% of participants self-reporting a diagnosis of IBS [3, 19]. Increased prevalence of IBS in MS may reflect common etiologic factors, or abnormalities associated with MS may predispose to IBS in susceptible individuals. Specifically, IBS has been associated with increased immune activation, altered cytokine profiles, and altered brain structures and activation patterns when compared to healthy controls [20, 21], all abnormalities seen in MS. The presence of one chronic condition may also increase the chances of another condition being diagnosed due to ‘surveillance bias’ created by increased health services use, a particularly important consideration for conditions such as IBS in which many persons remain otherwise undiagnosed. For example, a survey of more than 5,000 persons found that while 14.1% met the criteria for IBS, only 3.3% reported a current diagnosis of IBS [22].

The prevalence of IBD was much lower than that of IBS, although this still affected a higher proportion of the MS population than the GPOP. In other non-population-based studies the reported prevalence of IBD in MS has been as high as 3.5% [23], and most did not find a difference in prevalence versus the GPOP [24]. Even a large Canadian study of 5,031 persons with MS found no difference in IBD prevalence versus controls [25], although the use of spousal controls with the potential for over-matching or assortative mating likely masked an association [26]. A more recent study that used administrative data and GPOP controls found a 1.7-fold increased risk of IBD before MS diagnosis [8].

In 2005, nearly 16% of persons with MS in Manitoba had CLD. Few comparable studies of CLD in MS exist, as most either focused solely on asthma or COPD, or were not population-based. In 2010, reportedly only 5.7% of the Taiwanese MS population had asthma or COPD, although their prevalence in the GPOP was also much lower (2.2%), possibly reflecting differences in the underlying susceptibility of this population to CLD [27].

Prior studies have estimated that migraine affects 18–55% of persons with MS [3, 30] but few were population-based [30], and only one used controls [31]. In our population-based study, migraine affected 23% of the MS population, a prevalence 30% higher than in the GPOP. As with IBS, this higher prevalence may represent a surveillance bias, since individuals with MS are often followed closely by neurologists and interferon-β, a commonly used therapy for MS, may be associated with emergence of headache [32]. Regardless, the high prevalence of migraine in MS suggests that it may be an important cause of morbidity, and our findings suggest that administrative data can provide a valid method of surveillance of migraine within the MS population.

A study limitation was that medical records review for the validation cohort did not involve all records of all health care providers. For practical reasons we also compared medical records to administrative data for the 1- to 5-year period ending in fiscal year 2005/06, rather than from 1984 onward, potentially contributing to some disagreement between data sources. We have not developed methods to assess all of the comorbidities which potentially are relevant to persons with MS. Of particular relevance to pursue may be ischemic heart disease and stroke, based on work by Danish investigators [33], as well as mental comorbidities which are known to be common in MS but remain understudied at the population level [34]. We could not examine the impact of risk factors on the prevalence of comorbidity. This study had several strengths, however. We validated the case definition in a
population similar to the one in which it was applied, the design was population-based, we used matched controls from the GPOP, and we used inpatient and outpatient data. We showed that administrative data provide a valid means of assessing the prevalence of CLD, migraine and epilepsy in MS, but are suboptimal for IBS. A case definition for IBD still needs to be validated in the MS population. Migraine, epilepsy, IBS and IBD affect persons with MS more often than the GPOP. Collectively, these conditions tend to be episodic, adversely affect quality of life, and are associated with mood disorders in the GPOP [18, 35]. Their substantial prevalence in persons with MS warrants further evaluation of their impact on outcomes in MS, including disability and quality of life.

Acknowledgment

The results and conclusions presented are those of the authors. No official endorsement by Manitoba Health is intended or should be inferred.

This study was funded by operating grants and a Don Paty Career Development Award from the Multiple Sclerosis Society of Canada, the Manitoba Health Research Council, the Canadian Institutes for Health Research, and the Rx & D Health Research Foundation.

Disclosure Statement

Ruth Ann Marrie receives research funding from: Canadian Institutes of Health Research, Public Health Agency of Canada, Manitoba Health Research Council, Health Sciences Centre Foundation, Multiple Sclerosis Society of Canada, Multiple Sclerosis Scientific Foundation, Rx & D Health Research Foundation, and has conducted clinical trials funded by Bayer Inc. and Sanofi-Aventis.

Nancy Yu receives research support from the Canadian International Development Agency, the Multiple Sclerosis Society of Canada, CIHR, and Manitoba Health and Healthy Living.

Stella Leung reports no disclosures.

Lawrence Elliott receives research support from the Canadian Institutes of Health Research, Public Health Agency of Canada, and the Multiple Sclerosis Society of Canada.

Patricia Caetano has worked on a research project funded by Amgen.

Sharon Warren receives research funding from the CIHR, the Canadian Health Services Research Foundation, Alberta Health Services and SSHRC.

Christina Wolfson receives research funding from the Multiple Sclerosis Society of Canada, Canadian Institutes of Health Research, Canada Foundation for Innovation, and Public Health Agency of Canada.

Scott Patten was a member of an advisory board for Servier, Canada. He has received honoraria for reviewing investigator-initiated grant applications submitted to Lundbeck and Pfizer and has received speaking honoraria from Teva and Lundbeck. He is an Associate Editor for the Canadian Journal of Psychiatry and a member of the editorial board of Chronic Diseases and Injuries in Canada. He is the recipient of a salary support award (Senior Health Scholar) from Alberta Innovates, Health Solutions and receives research funding from the Canadian Institutes for Health Research, the Institute of Health Economics and the Alberta Collaborative Research Grants Initiative.

Larry Svenson reports no disclosures.

Helen Tremlett currently receives funding from: the Multiple Sclerosis Society of Canada (Don Paty Career Development Award); US National MS Society [RG 4202-A-2 (PI) ]; Canadian Institutes of Health Research [MOP: 190898 (PI) and MOP-93646 (PI) ]; Michael Smith Foundation for Health Research (Scholar Award) and the Canada Research Chair program. She has received speaker honoraria and/or travel expenses to attend conferences from: the Consortium of MS Centres, US National MS Society, Swiss Multiple Sclerosis Society, the University of British Columbia Multiple Sclerosis Research Program, Teva Pharmaceuticals and Bayer Pharmaceutical (honoraria declined) and ECTRIMS. Unless otherwise stated, all speaker honoraria are either donated to an MS charity or to an unrestricted grant for use by her research group.

John Fisk is the Director of the endMS Atlantic Regional Research and Training Centre, which is funded by the Multiple Sclerosis Society of Canada. He receives research funding from the Canadian Institutes of Health Research (CIHR) and in the past has received grants, honoraria and consultation fees from AstraZeneca, Bayer, Biogen-Idec Canada, Heron Evidence Development Limited, Hoffmann-La Roche, MAPI Research Trust, Novartis, Sanofi-Aventis, Serono Canada, and QualityMetric Inc.

James Blanchard receives research support from the Multiple Sclerosis Society of Canada, CIHR, Bill and Melinda Gates Foundation, Canadian International Development Agency and the United States Agency for International Development.

References


Elizhauser A, Steiner C, Harris DR, Coffey RM: Comorbidity measures for use with administrative data. Med Care 1998;36:8–27.


